



# Impact of Lockdown on Air Pollutant Variation in Metropolitan Cities

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## Abstract

In early 2020, the COVID-19 pandemic swept the globe. In many countries, the complete lockdown resulting from the COVID-19 outbreak helped improve air quality, particularly in developing countries such as India. The main aim of the study is to assess the variation in AOD and various atmospheric pollutants such as  $PM_{2.5}$ ,  $PM_{10}$ ,  $NO_2$ ,  $SO_2$ , and  $O_3$  before and after the lockdown. The data source used for the current study includes MODIS-Aqua, OMI, and ground-based monitoring data gathered from Central Pollution Control Board (CPCB). Time-averaged maps of Aerosol Optical Depth (AOD) at 500 nm, daily  $1^\circ$  [OMI OMAERUVd v003], and at 550 nm (Deep Blue, Land-only) daily  $1^\circ$  [MODIS-Aqua MYD08\_D3 v6.1] were plotted on NASA's Giovanni during 2010–2020. The data was extracted during the lockdown phases in India from March 25, 2020, to May 17, 2020. During the same period, changes in mean AOD were assessed during 2010–2019. Significant reductions were observed in mean AODs. Similarly, changes in the concentration of other pollutants were observed in the study areas during COVID. Fluctuations in the contaminants have also resulted from changes in meteorological conditions; hence, the impact of wind speed, temperature, and humidity are also studied on changing pollutant concentrations. This is owing to a reduction in local emissions resulting from anthropogenic activities due to the pandemic-control lockdown procedures. This work aids in visualizing pollutant responses in metropolitan cities as a result of reduced anthropogenic emissions, which can aid in developing atmospheric governance strategies.

## Keywords

AOD · COVID-19 · Air pollutants · Metropolitan cities

## 1 Introduction

COVID-19, a novel coronavirus, was initially discovered in December 2019 and has since spread around the globe (Prakash et al., 2021; Verma & Kamyotra, 2021). Public isolation and lockdown resulted in a considerable reduction in global air pollution emissions (Bao & Zhang, 2020; Pal et al., 2021; Yadav et al., 2020).

This research looks at how air pollutant levels changed in India's six megacities based on ground and space-derived data during the COVID-19 shutdown compared to the previous years under typical conditions.

## 2 Research Area and Data Sources

The study area counts six megacities of India and time-averaged maps of Aerosol Optical Depth (AOD) at 500 nm, daily  $1^\circ$  [OMI OMAERUVd v003], and at 55 nm (Deep Blue, Land-only) daily  $1^\circ$  [MODIS-Aqua MYD08\_D3 v6.1] were plotted on NASA's Giovanni during 2010–2020. A dataset spanning five primary types of air contaminants, including  $PM_{2.5}$ ,  $PM_{10}$ ,  $NO_2$ ,  $SO_2$ , and  $O_3$ , makes up the air quality data obtained from Central Pollution Control Board (CPCB). Meteorological data were obtained from [www.worldweatheronline.com](http://www.worldweatheronline.com).

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### 3 Results

#### 3.1 Differences in the Concentrations of Aerosols and Trace Gases

Table 1 shows the difference in AOD concentrations in the megacities, and estimates from the OMI satellite and the MODIS model revealed a considerable decrease in column AOD. A mean reduction in AOD in all the megacities is  $-0.42\%$ , as estimated by OMI and  $-0.06\%$  by MODIS. The alteration in pollutants in lockdown was compared to the mean daily pollutants of earlier accessible years to present a comparative measurement of relative improvement in comparison to pre-lockdown circumstances (2018–2019, all through megacities).

Pollutant emissions in the atmosphere such as  $PM_{2.5}$ ,  $PM_{10}$ ,  $NO_2$ ,  $SO_2$ , and  $O_3$  changed during the lockdown phase up to  $-71\%$ , NA,  $-66\%$ ,  $-35\%$ ,  $-13\%$  in Ahmedabad,  $-40\%$ ,  $-51\%$ ,  $-72\%$ ,  $52\%$ ,  $32\%$  in Bangalore,  $-56\%$ ,  $-65\%$ ,  $-79\%$ ,  $-34\%$ ,  $59\%$  in Delhi,  $-48\%$ ,  $-46\%$ ,  $-44\%$ ,  $78\%$ ,  $100\%$  in Hyderabad,  $-41\%$ , NA,  $-69\%$ ,  $-28\%$ ,  $9\%$  in Kanpur, and  $28\%$ ,  $-18\%$ ,  $-51\%$ ,  $51\%$ ,  $-20\%$  in Mumbai, respectively. Figure 1 shows the plots of mean pollutant concentration data during

the pandemic year (March 25–May 17) in 2020 and during the same period in 2018–2019.  $PM_{2.5}$  and  $PM_{10}$  showed a reduction in all the megacities except in Mumbai, where  $PM_{2.5}$  levels increased up to  $28\%$ .

#### 3.2 Influence of Meteorology

An overall  $7.2\%$  temperature decrease is observed in megacities during lockdown, which may be due to the minimization of human activities and vehicular movement (Pal et al., 2021). A slight increase in wind speed of up to  $6\%$  is noticed in the cities except in Kanpur, and in other towns where wind speed is increased during the lockdown period, which might have helped in the improved scattering of pollutants. The  $4\%$  increase in RH in the cities, except Kanpur, is the reason behind the pollutant concentrations' decrease (Fig. 2).

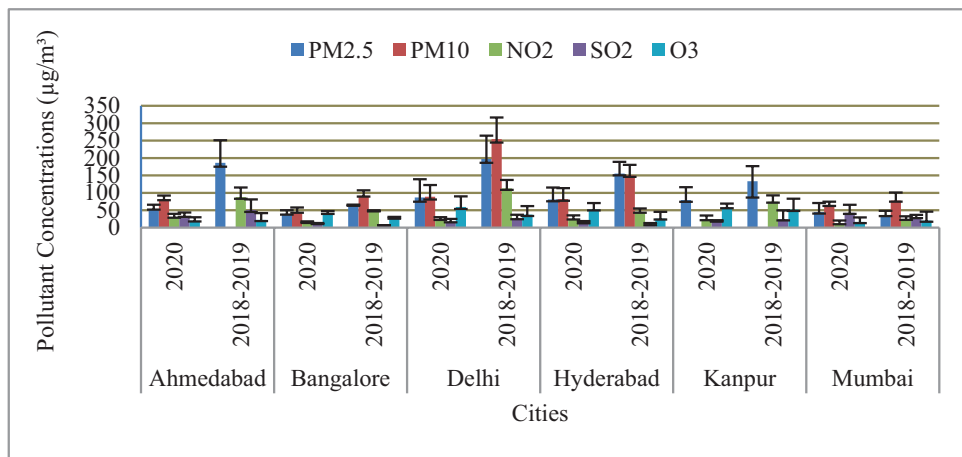
### 4 Discussion

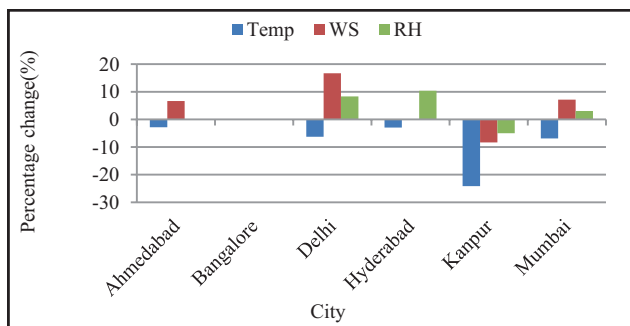
The key atmospheric pollutants AOD,  $PM_{2.5}$ ,  $PM_{10}$ ,  $NO_2$ ,  $SO_2$ , and  $O_3$  declined during the lockdown phase in the selected megacities compared to previous years' data.

**Table 1** Difference in AOD concentrations in six megacities of India during lockdown (March 25, 2020–May 17, 2020) and before lockdown during the same period from 2010 to 2019

Cities	OMI (mean) 2010–2019	2020	Difference	% reduction	MODIS (mean) 2010–2019	2020	Difference	% reduction
Ahmedabad	0.30	0.21	$-0.28$	$-27.84$	0.27	0.21	$-0.02$	$-1.85$
Bangalore	0.44	0.21	$-0.51$	$-50.69$	0.30	0.10	$-0.06$	$-6.15$
Delhi	0.46	0.21	$-0.53$	$-53.09$	0.56	0.41	$-0.08$	$-8.11$
Hyderabad	0.39	0.30	$-0.23$	$-23.08$	0.50	0.50	0.00	0.10
Kanpur	0.48	0.21	$-0.55$	$-55.45$	0.65	0.41	$-0.15$	$-14.97$
Mumbai	0.36	0.21	$-0.42$	$-42.29$	0.38	0.21	$-0.06$	$-6.30$

**Fig. 1** Impact of lockdown on air pollution levels during two situations, i.e., during lockdown (March 25, 2020–May 17, 2020) and mean concentrations before lockdown during the same period in 2018–2019





**Fig. 2** Percentage changes in meteorological parameters, including temperature, wind speed, and relative humidity in the selected megacities of India

Overall change in mean pollutant concentrations including  $PM_{2.5}$ ,  $PM_{10}$ ,  $NO_2$ ,  $SO_2$ , and  $O_3$  including all the cities is  $-38\%$ ,  $-45\%$ ,  $-64\%$ ,  $14\%$ , and  $35\%$ , respectively. In cities like Delhi, vehicular emissions are one of the emitters of  $PM_{2.5}$ ; hence, lockdown minimizes the  $PM_{2.5}$  levels (Shrestha et al., 2020).  $NO_2$  concentrations were reduced in all the areas, which may be due to a pause in vehicular and transportation activities (Pal et al., 2021).  $SO_2$  concentrations increased in Bangalore, Hyderabad, and Mumbai from biomass burning and industrial emissions that may not have been turned down (Bar et al., 2021; Shrestha et al., 2020).  $O_3$  emissions often follow the reverse trend as the other trace gases in all regions except in Ahmedabad and Mumbai. The established tight controls have resulted in a significant reduction in vehicle movement and the closure of certain industries, resulting in an improvement in air quality. Such a significant drop in pollution levels is expected to improve public health and prevent health issues and mortality rates linked to air pollution.

## 5 Conclusions

The research examined six key air contaminants to see how air quality changed after the COVID-19 pandemic curtailed human activity in 6 Indian megacities from March 25, 2020–May 17, 2020, and the same period during 2010–2019. Almost all the contaminants, excluding  $SO_2$  and  $O_3$ , were reduced during the lockdown period. Spatial and ground-based data affirm that general air pollution levels have been greatly influenced following the pandemic. Reduced pollution levels have occurred due to the closure of industrial activities and a decline in vehicular movement during the lockdown phase. According to the study, strict enforcement of air pollution regulations could be an alternate tool for pollution control in industrial and transportation-dominated areas.

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